The Balloon Lidar Experiment BOLIDE

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ESA-PAC Symposium

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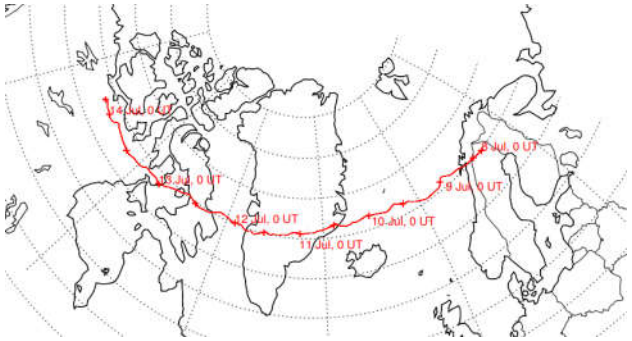
PMC Turbo Mission

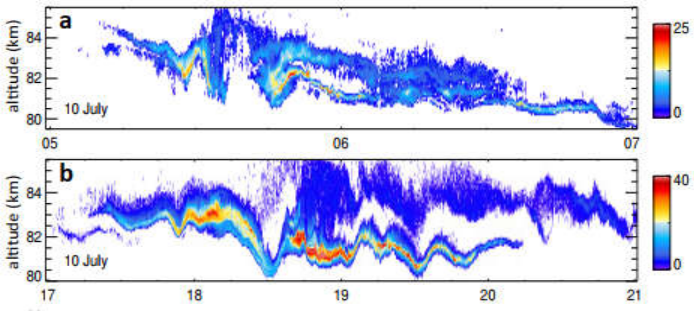
- NASA long duration balloon
- Six-day flight from Esrange to Canada in July 2018
- 38 km floating altitude

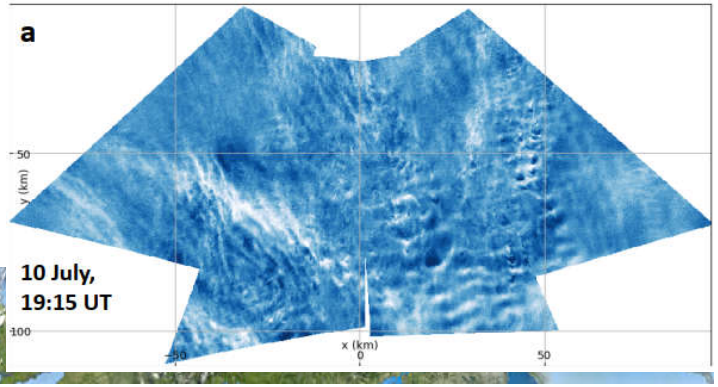
Scientific payload for high-resolution observations of Noctilucent Clouds (NLC)

- **Rayleigh lidar BOLIDE**
  - **Vertical profiling of the NLC layer (79-86 km)**
  - **Temperature soundings of gravity waves (45-80 km)**

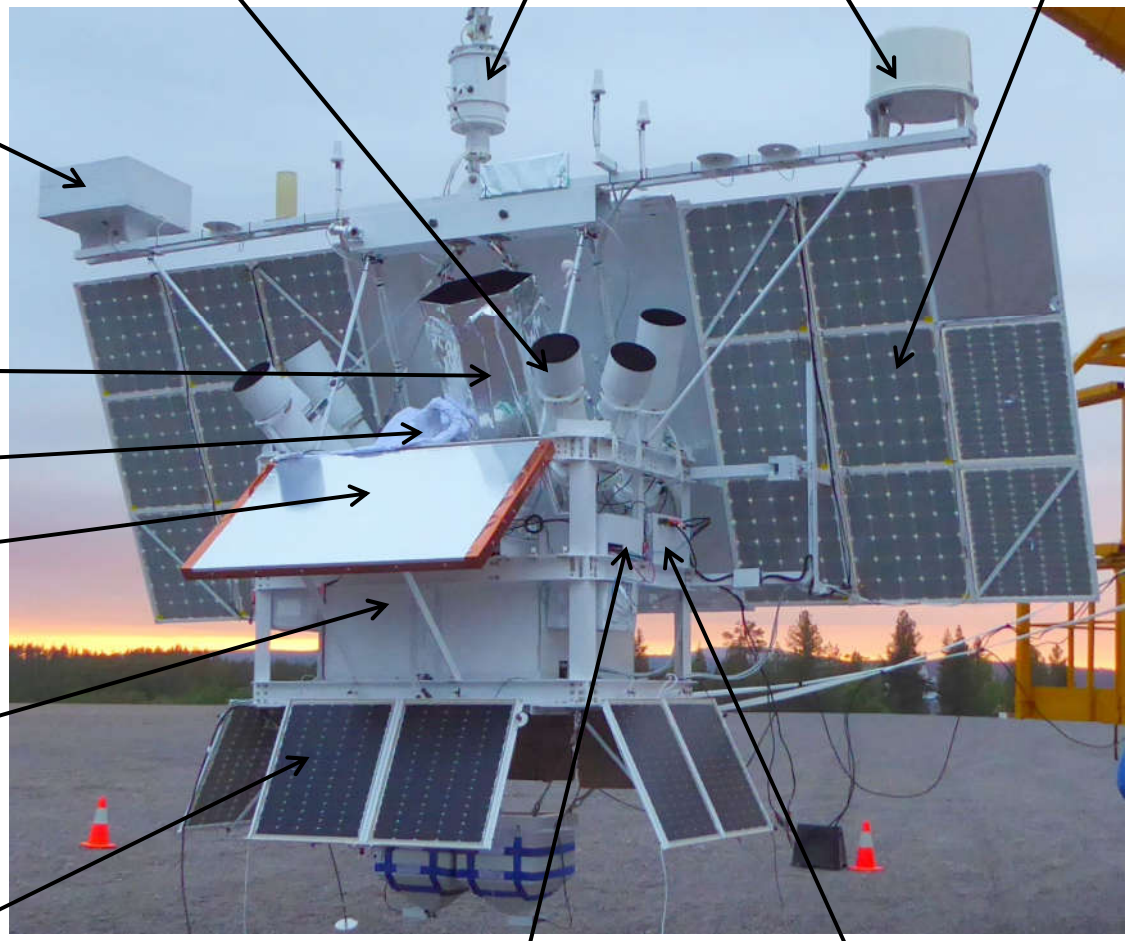
- Seven digital cameras for imaging of the NLC layer







PMC Turbo Payload



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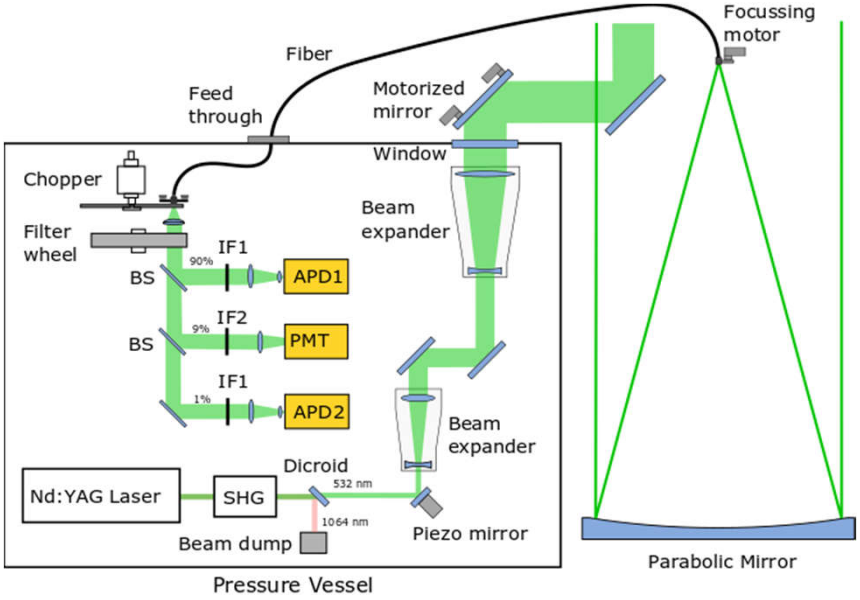
Optical System

Laser

- 4.5 W at 532 nm
- 28 deg off-zenith pointing
- 100 Hz pulse repetition frequency
- 1.5 m pulse length

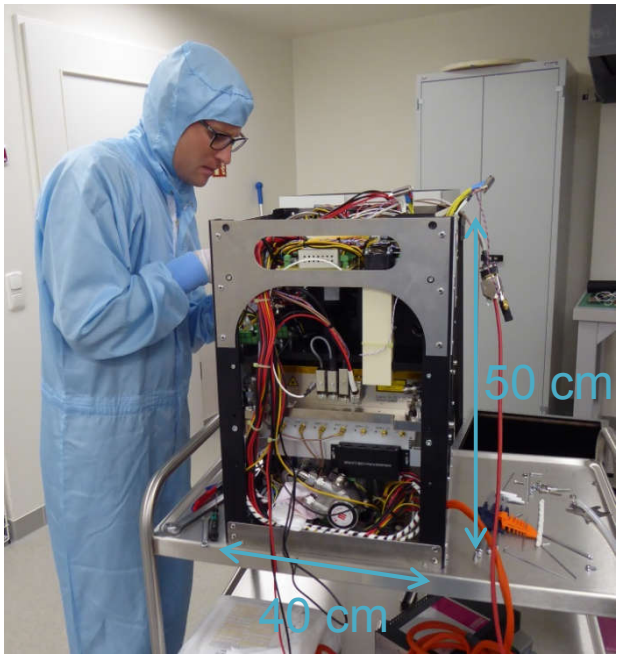
Receiver

- 50 cm telescope with 160 µrad FOV
- Three cascaded detector channels with 0.3 nm wide filters
- Mechanical chopper and filter wheel with ND filters for ground tests



Instrument Parameters

Dimensions	
Telescope	55 cm x 55 cm x 140 cm
Pressure vessel	48 cm x 48 cm x 68 cm
Radiator	175 cm x 100 cm x 8 cm
Total mass	151 kg
Power	28 VDC, 320 W + 220 W bias heaters
Cooling	Glycol loop with radiator
Telemetry	8 kbit/s
Onboard Storage	3x 1 TB (30 day flight)



Rack inside the pressure vessel

Design Challenge: Near-space Environment

- Low atmospheric pressure
- Radiative heating and cooling
- Forced convection during ascent, cold tropopause

Not on the ground, not quite a satellite platform, and flies too long for a suborbital rocket – A thermal engineers‘ nightmare

Key design aspects

- A highly efficient radiator to minimize external influences
- Thermal decoupling of instrument and gondola (insulation, radiation shields)

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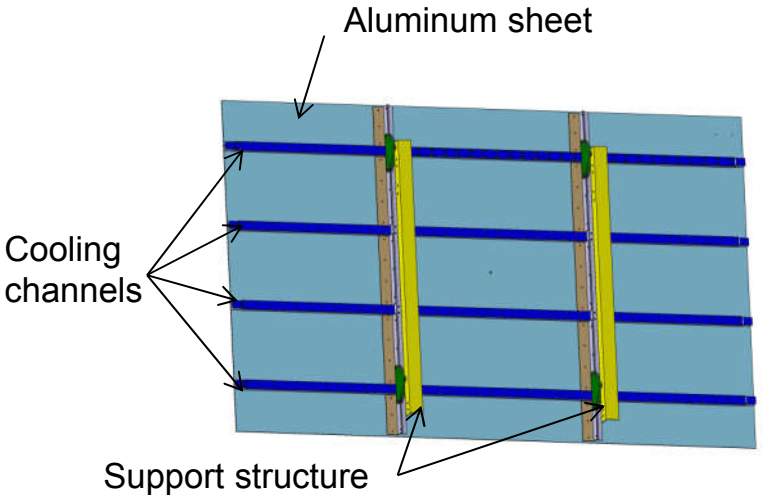
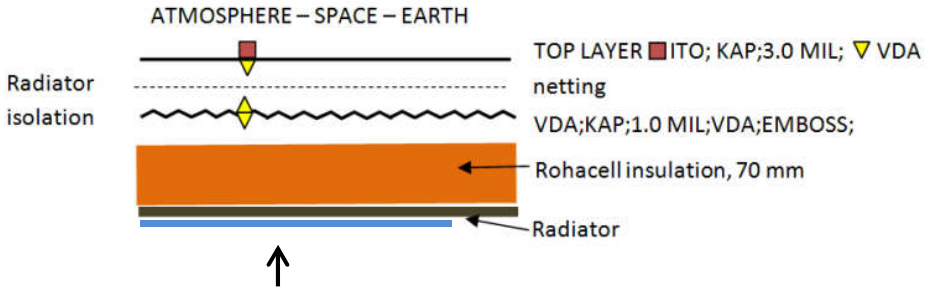
Radiator Design

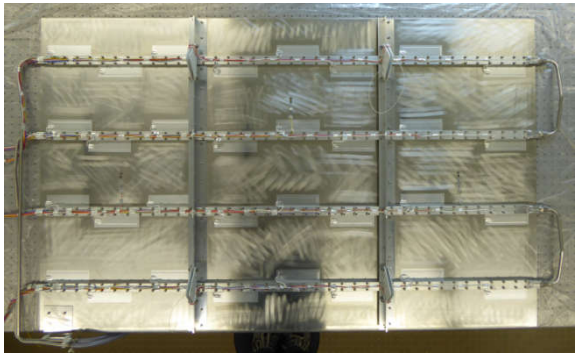
Backside of radiator without Insulation



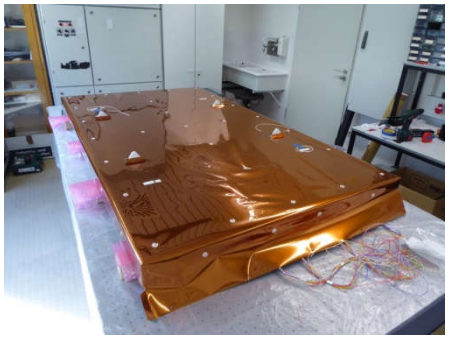
Structure back to front



Active surface:
Optical coating FEP 10 mil with VDA



Back side



Front

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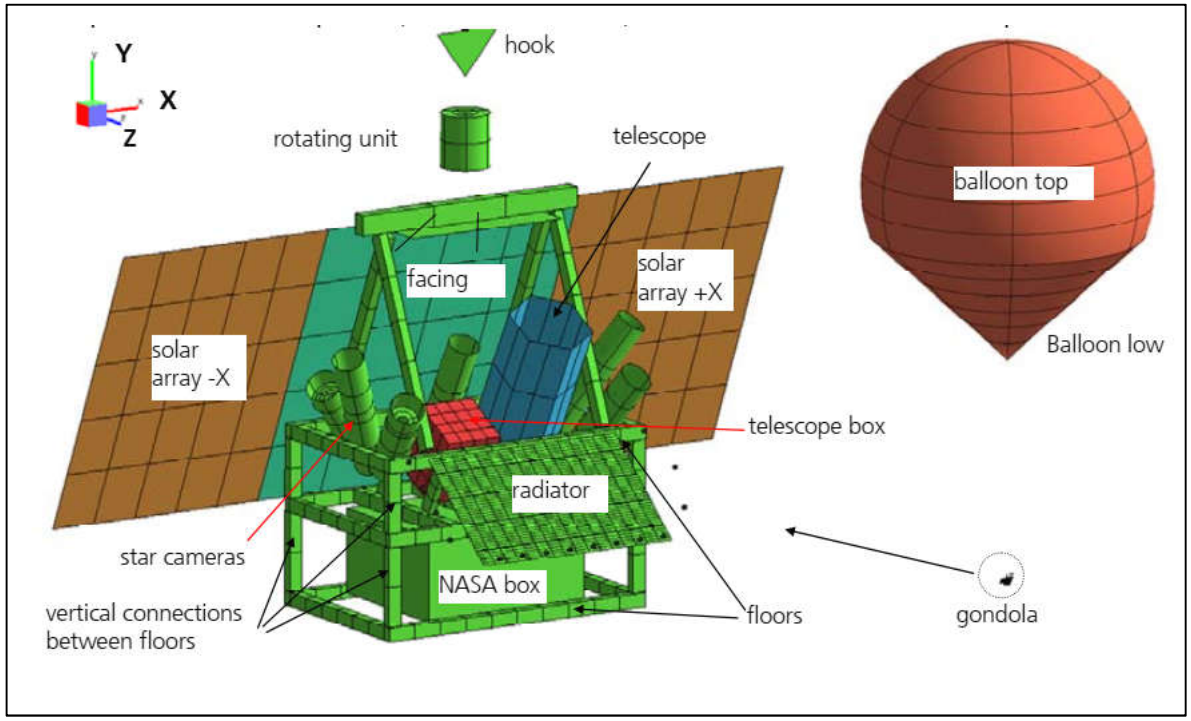
Thermal Analysis with ESATAN TMS 2017

Model includes

- Solar radiation
- Albedo
- IR radiaton
- Thermal radiation from gondola

Geometric model

- Anti-solar pointing gondola
- 1.6 m^2 radiator at backside of gondola with 40° inclination



Geometric model used in thermal analysis

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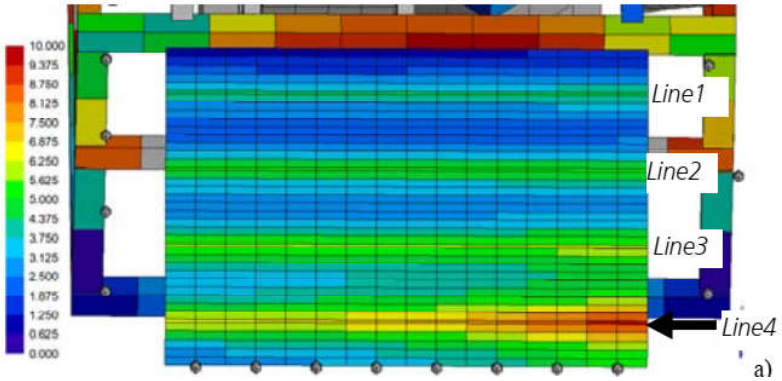
Predicted Performance of the Radiator

Target:
Coolant temperature 17°C

Required heat load

Cold Case (Local midnight)	**470 W**
Hot Case (Local noon)	**320 W**



Hot Case Simulation

Temperature can be controlled by powering additional heaters

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Predicted Performance of the Radiator

Target:
Coolant temperature 17°C

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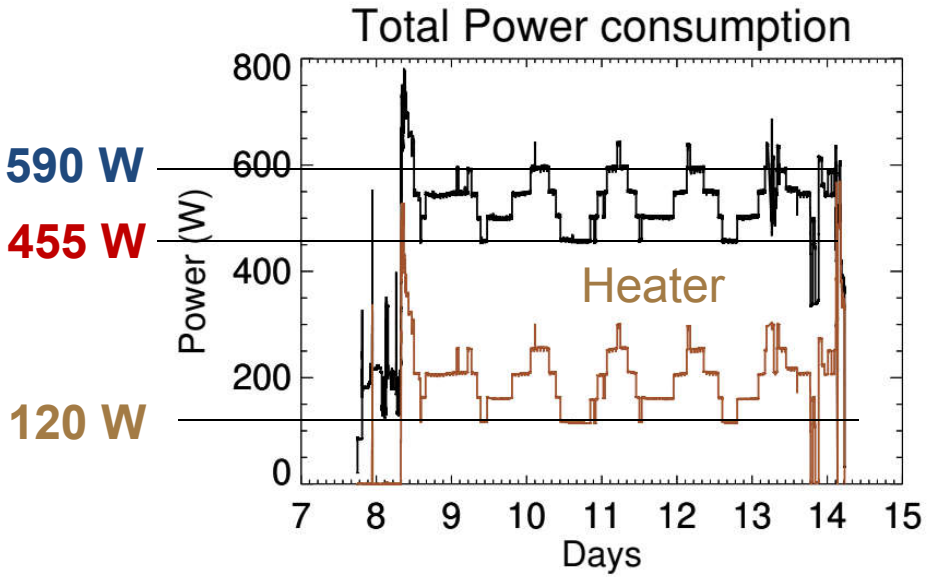
Temperature can be controlled by powering additional heaters

In-flight Performance



- Radiator is more efficient than anticipated
- Accurate modeling of heat transfer from liquid to wall is difficult

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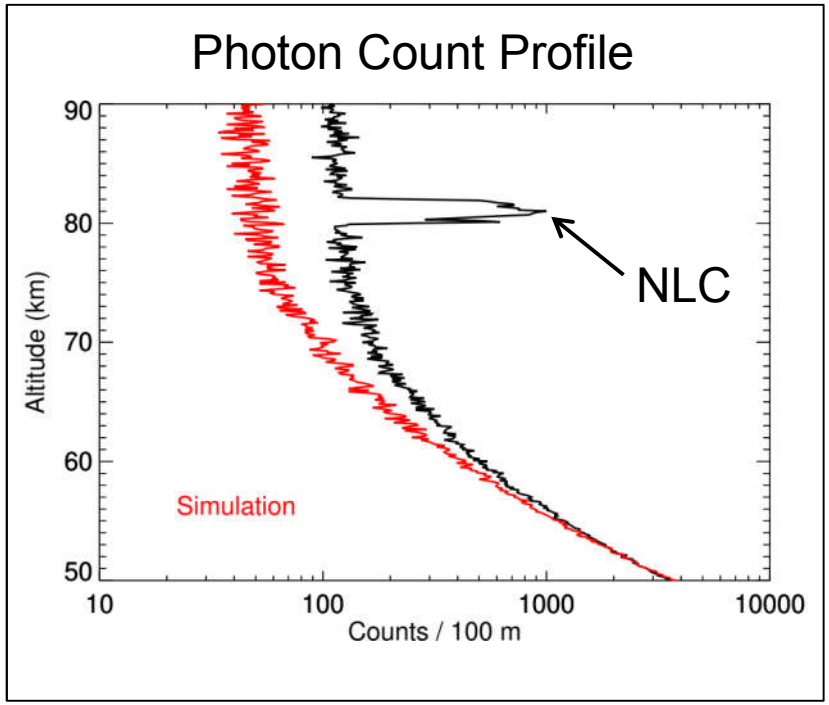
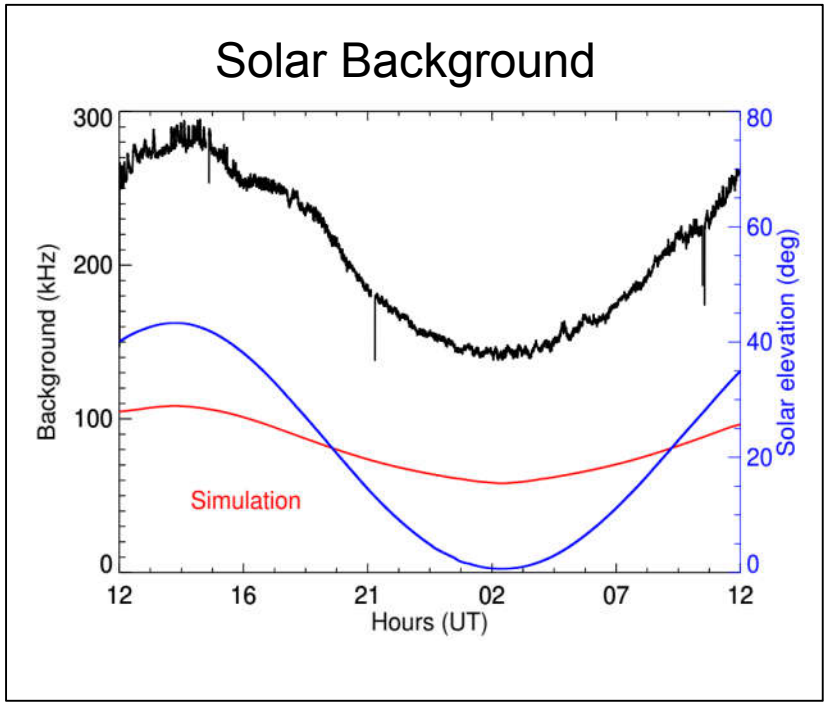
Lidar Performance





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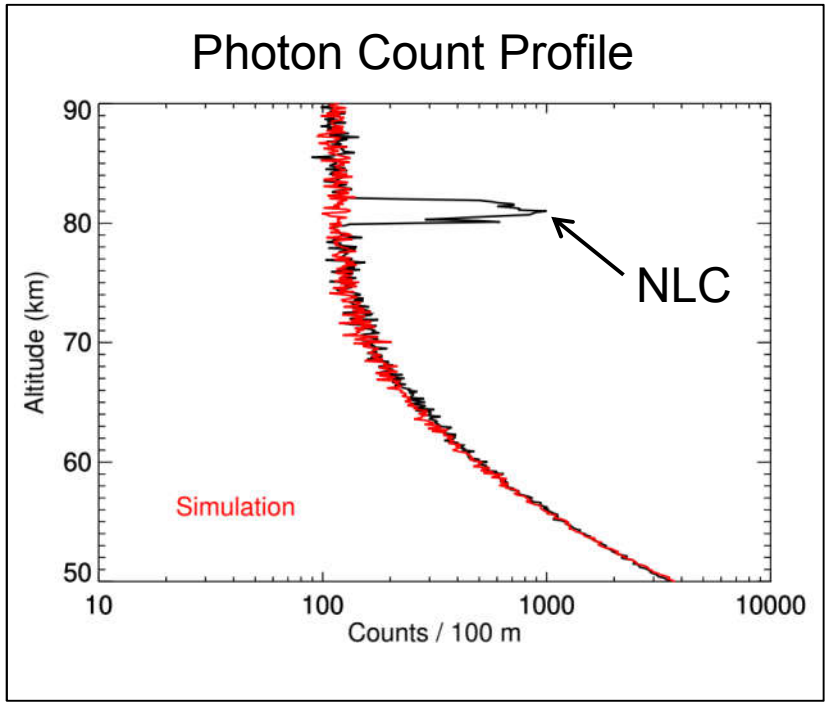
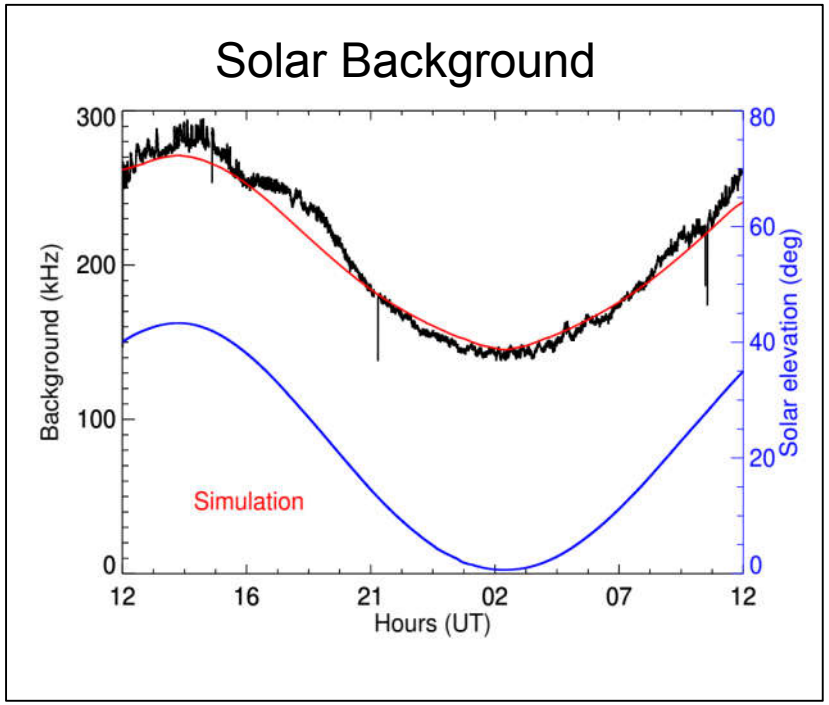
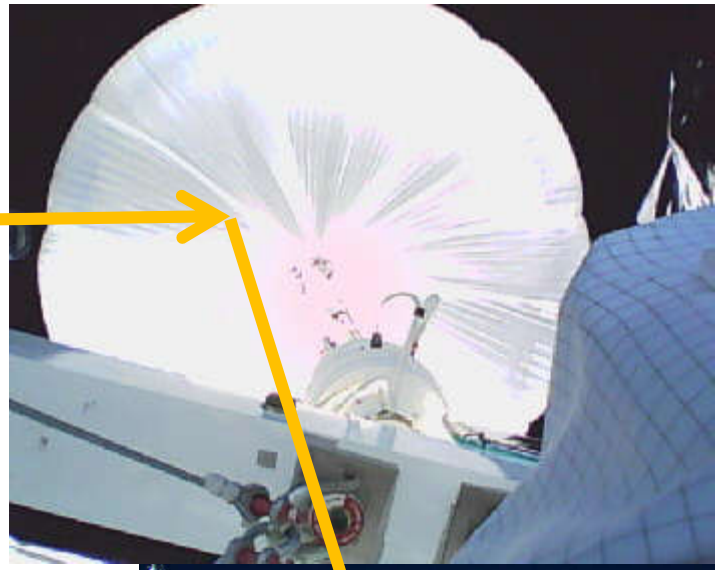
Lidar Performance

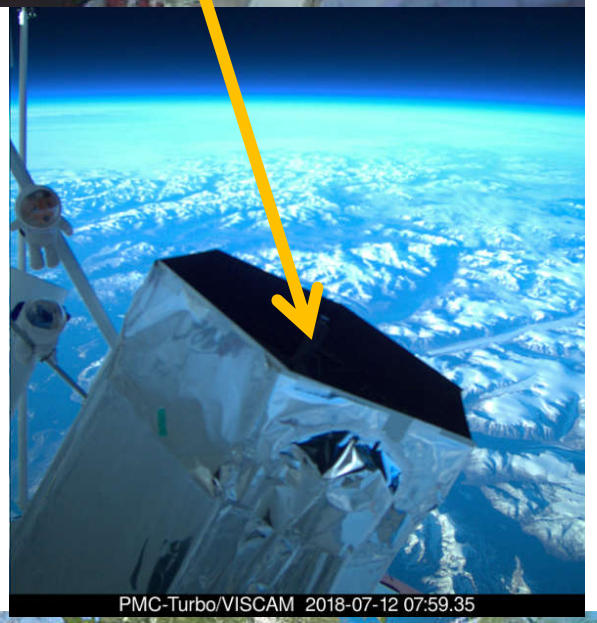
Simulated backgrond * 2.5





Enhanced Background



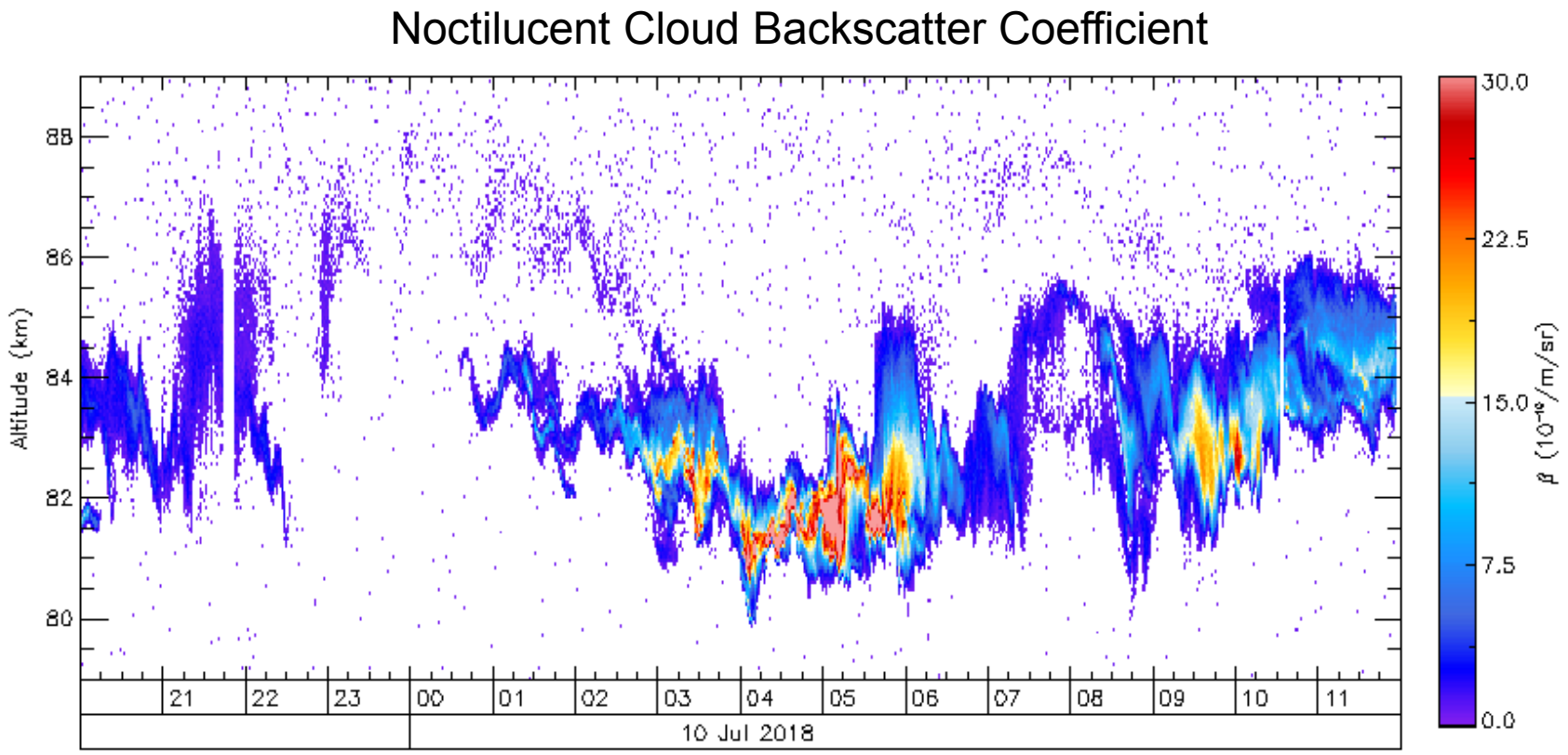


Sun light scattered off the balloon hits the spider of the telescope and is scattered into the optical path of the receiver

-> 2.5 times larger LIDAR background

Baffle design is important!

Fantastic Data



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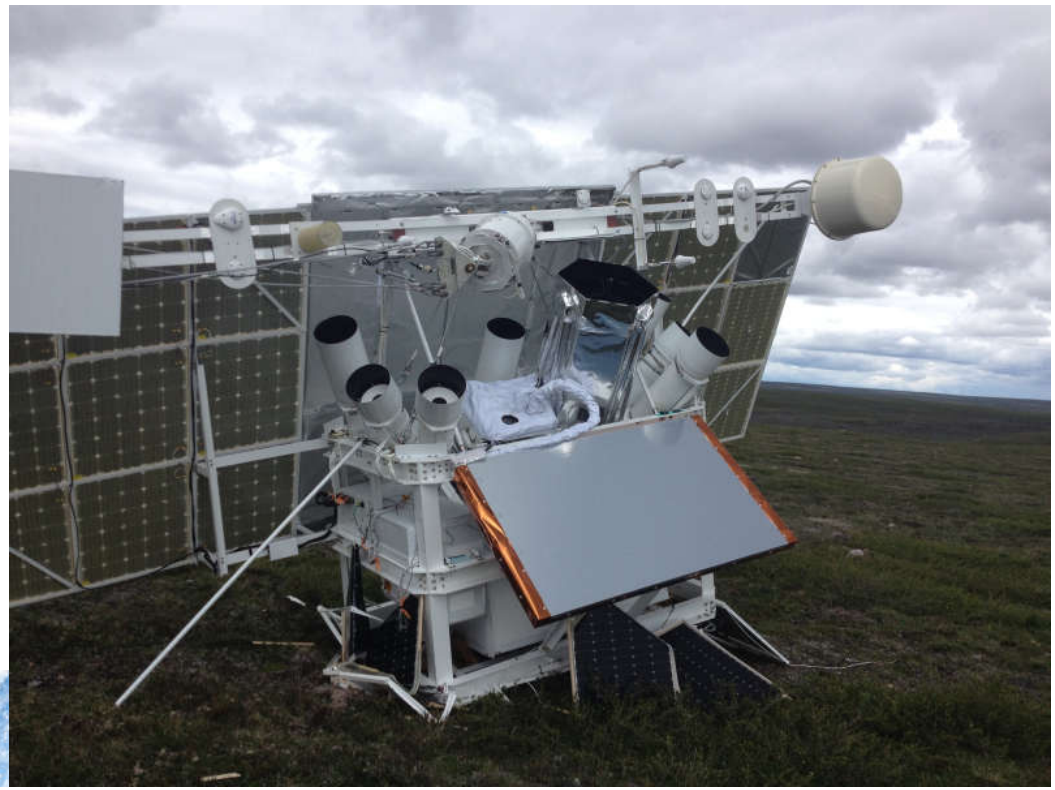
Summary

- BOLIDE is the first mesospheric lidar system onboard a long duration balloon
- The instrument obtained vertical profiles of Noctilucent Clouds and mesospheric temperature at high resolution
- Cooling system was more efficient than predicted
- Lidar performed as expected
- Baffle design is important

Mission was a great success!

Survived landing



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